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The Laursen-Metzler Effect Under Currency Substitution

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College of Commerce and Business Administration

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The Laursen-Metzler Effect Under Currency Substitution

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ABSTRACT

A permanent unanticipated terms of trade shock is analyzed in a flexible exchange rate world where agents hold their financial wealth in the form of domestic and foreign currencies. The terms of trade deterioration is found to be accompanied by a trade balance deficit but increased saving.

1. INTRODUCTION

Recently there has been a renewal of interest in the effects of changes in terms of trade for a small open economy. The conventional wisdom, first put forward by Laursen and Metzler (1950) and Harberger (1950), emphasized the fact that a terms of trade worsening lowered real income. This in turn lowered savings and worsened the current account. A terms of trade deterioration therefore worsens the current account--the Laursen-Metzler Effect.

The recent reappraisal was initiated by Obstfeld (1982). He showed in an optimizing framework that if the discount rate was a function of the level of utility, surpluses, and not deficits, accompany an unanticipated and permanent terms of trade worsening. The long run level of the discount rate is tied down by the given world rate of interest. This in turn fixes the long run level of utility. The terms of trade shock tends to lower the level of utility and agents save to offset this. Across steady states there is only a substitution effect. On the other hand, if the discount rate is fixed and equal to the world interest rate then the economy adjusts to the terms of trade shock by immediately lowering real expenditure by the same amount as the decline in real income so that the current account is always balanced. This result is obtained in an overlapping generations framework by Persson and Svensson (1985).¹

Svensson and Razin (1983) showed that in a two period framework this does not necessarily happen. For the infinite-horizon case they showed that if preferences were separable over time and the discount rate was increasing in instantaneous utility then Obstfeld's results were indeed obtained.

In this paper we re-examine the Laursen-Metzler effect in a currency substitution framework. Four factors motivate this analysis. First, the original Laursen-Metzler analysis was carried out in a monetary economy whereas the recent papers have been set in a barter world. Second, in the infinite horizon models both the fixed and the variable discount rate cases imply a very sharp expenditure (and utility) reduction in the face of an unanticipated, permanent adverse shift in the relative price of the domestic good. Thirdly, currency substitution allows us to set up a model where the small open economy does not have access to the world capital markets--not an unrealistic assumption for economies facing fixed terms of trade--and yet allows for imbalances in trade. Finally, the presence of the two assets makes it possible to draw a distinction between saving and the current account [see Persson and Svensson (1985) and Sachs (1981) on this point].

The major conclusion that emerges from our analysis is that consumers adjust to an unanticipated terms of trade shock by first increasing expenditure and then slowly over time reducing it to bring it in line with the lower level of real income. The agents therefore smooth consumption in response to the decline in real income. Aggregate expenditure shows considerable serial correlation in spite of the fact that agents are forward-looking.

The paper is organized as follows. In Section 2 we set up the model. The dynamic behavior and the steady state of the model are examined in Section 3. Section 4 examines the effects of terms of trade shock. Section 5 extends the analysis to allow for production of the exportable. Finally, Section 6 summarizes the conclusions and limitations of our analysis.

2. THE MODEL

In our economy the representative agent derives utility from the consumption of two goods--a domestically produced good X whose output is fixed at Q and an importable Y--and two assets--real domestic money balances, m and real value of foreign money balances, g. The relative price of Y in terms of X, denoted by e, is fixed in the world market and cannot be affected by the small open economy. The nominal exchange rate is freely floating.

The agent, who has perfect foresight, maximizes the following utility functional:

$$\int_0^{\infty} \exp(-\delta t) [U(X(t), Y(t)) + V(m(t), g(t))] dt \quad (1)$$

where δ is the fixed discount rate. Note that utility from goods and moneys enter in an additively separable way.² Real money balances are defined to be nominal balances M defined by a price index P defined below. Similarly the real value of foreign money (g) is the nominal value in terms of the domestic currency Ef deflated by P. E is the nominal exchange rate defined as the domestic currency price of foreign exchange and f is the number of units of foreign currency in domestic portfolios. M which is non-traded, and f are the only assets so there is no borrowing or lending and agents are effectively liquidity constrained.³

The sub-utility functions U and V are assumed to be strictly concave, i.e.,

$$U_1 > 0, U_2 > 0, U_{11} < 0, U_{22} < 0, U_{11}U_{22} - U_{12}^2 > 0 \quad (2)$$

$$V_1 > 0, V_2 > 0, V_{11} < 0, V_{22} < 0, V_{11}V_{22} - V_{12}^2 > 0 \quad (3)$$

Throughout this paper a prime denotes a derivative of a function of a single variable and a subscript i the i^{th} partial derivative.

Further we assume U_{12} and $V_{12} > 0$ (co-operancy)⁴ and to ensure an interior solution the following hold

$$\begin{aligned}
 U_1(0,Y) &\rightarrow \infty & U_2(X,0) &\rightarrow \infty \\
 U_1(\infty,Y) &\rightarrow 0 & U_2(X,\infty) &\rightarrow 0 \\
 V_1(0,g) &\rightarrow \infty & V_2(m,0) &\rightarrow \infty \\
 V_1(\infty,g) &\rightarrow 0 & V_2(m,\infty) &\rightarrow 0
 \end{aligned} \tag{4}$$

The sub-utility function U is assumed to be homothetic so that we can write

$$U = \theta[Z(X,Y)] \tag{5}$$

where Z is linearly homogeneous in its arguments and θ is an increasing (strictly concave) function.

Real wealth (a) at each instant is the sum of real domestic and foreign balances

$$a \equiv m + g \tag{6}$$

The price index P used to deflate M and E_f is given by

$$P \equiv P(q, E_q^*) \tag{7}$$

where $q(q^*)$ is the domestic (foreign) currency price of a unit of $X(Y)$. P is homogeneous of degree one and increasing in its arguments.

In what follows we set $q^* = 1$. The effect of a rise in q^* in this model is theoretically ambiguous⁵ (but see Sen (1986) for an analysis of an oil price shock where oil is an intermediate good).

It is useful to define two variables

$$\begin{aligned} h &\equiv q/P = h(e) \quad h' < 0 \\ j &\equiv E/P = j(e) \quad j' > 0 \end{aligned} \tag{8}$$

The consumers' flow budget constraint is given by

$$\dot{a} = hQ - hX - jY + T - (\dot{P}/P)m \tag{9}$$

where T is (lump-sum) transfers from the government and \dot{P}/P is the expected and actual rate of inflation of the price index P .

We shall refer to $hQ + T$ as "augmented real income" and $hX + jY + (\dot{P}/P)m$ as "augmented real expenditure" and reserve the terms real income and real expenditure for hQ (income from production) and $hX + jY$ (expenditure on goods) respectively.

The individual takes all prices as well as T as given. The optimization problem can then be written as

$$H = U(X,Y) + V(m, a-m) + \lambda [h(Q-X) - jY + T - (\dot{P}/P)m] \tag{10}$$

where H is the current-value Hamiltonian and λ is the co-state variable associated with (9). The first order conditions with respect to the control variables X, Y and m are

$$U_1(X,Y) = h\lambda \tag{11}$$

$$U_2(X, Y) = j\lambda \quad (12)$$

$$V_1(m, a-m) - V_2(m, a-m) = \lambda(\dot{P}/P) \quad (13)$$

Note (11) and (12) imply the usual static optimality condition

$$U_2/U_1 = e$$

In addition, we have the dynamic equations (9) and (14) below

$$\dot{\lambda} = \delta\lambda - V_2 \quad (14)$$

Finally, we have transversality conditions

$$\exp(-\delta t) \lim_{t \rightarrow \infty} \lambda(t) \geq 0 \quad (15)$$

$$\exp(-\delta t) \lim_{t \rightarrow \infty} \lambda(t)a(t) = 0$$

In the present model these conditions given the strict concavity of U and V are also sufficient for maximizing (1).

For the economy as a whole, real domestic money balances evolve according to

$$\dot{m}/m = \mu - \dot{P}/P \quad (16)$$

where μ is the constant rate of growth of the nominal money stock. We assume that the authorities change T to keep μ a positive constant.

Finally, the economy acquires foreign money by running a current account surplus, i.e.,

$$jf = h(Q-X) - jY \quad (17)$$

Note that in the absence of interest bearing assets the trade balance and the current account are identical.

3. DYNAMICS AND STEADY-STATE

From equations (11) and (12) we can solve for X and Y as functions of λ and e

$$X = X(\lambda, e) \quad (18)$$

$$Y = Y(\lambda, e) \quad (19)$$

where $X_1 = j(U_{22} - U_{12}e)/D < 0$

$$Y_1 = j(eU_{11} - U_{12})/eD < 0$$

$$X_2 = \lambda(h'U_{22} - j'U_{12})/D \gtrless 0$$

$$Y_2 = \lambda(j'U_{11} - h'U_{12})/D \gtrless 0$$

and

$$D = U_{11}U_{22} - U_{12}^2 > 0.$$

Substituting for X and (Y) in (17) we get

$$\dot{f} = \dot{f}(\lambda; e) \quad (20)$$

Equation (14) can be rewritten as

$$\dot{\lambda} = \dot{\lambda}(f, \lambda, m; e) \quad (21)$$

and (16) with (13) substituted in can be rewritten as

$$\dot{m} = \dot{m}(f, \lambda, m; e, \mu) \quad (22)$$

Linearizing the system of differential equations (20)-(22) around a steady state we have (an overbar denotes a steady state value)

$$\begin{bmatrix} \dot{f} \\ \dot{\lambda} \\ \dot{m} \end{bmatrix} = [A] \begin{bmatrix} f - \bar{f} \\ \lambda - \bar{\lambda} \\ m - \bar{m} \end{bmatrix} \quad (23)$$

where $a_{11} = a_{12} = 0$

$$a_{13} = -j(U_{22} + U_{11}e - 2U_{12})/D > 0$$

$$a_{21} = -jV_{22} > 0$$

$$a_{22} = \delta > 0$$

$$a_{23} = -V_{21} < 0$$

$$a_{31} = jm(V_{22} - V_{12})/\lambda < 0$$

$$a_{32} = \mu m/\lambda > 0$$

$$a_{33} = m(V_{21} - V_{11})\lambda > 0$$

are the elements of the coefficients matrix A.

The trace of the matrix A is positive and its determinant negative. These together imply that one characteristic root of A is negative and the others are positive. The long run equilibrium is a saddle point and along the stable arm we have

$$f(t) = \bar{f} + k \exp(st) \quad (24)$$

$$\lambda(t) = \bar{\lambda} + kn_1 \exp(st) \quad (25)$$

$$m(t) = \bar{m} + kn_2 \exp(st) \quad (26)$$

where $k = f(0) - \bar{f}$ and $[1, n_1, n_2]'$ is the eigenvector associated with the stable root s .

It is easily checked that n_1 and n_2 are both negative. For an unanticipated change in the terms of trade we assume that the system jumps to the saddle path by jumps in λ and m .⁶ For the flexible exchange rate regime f is given by past trade balance surpluses and deficits since M is nontraded by assumption.

The steady state of the economy is characterized by $\dot{f} = \dot{\lambda} = \dot{m} = 0$.

From (11), (12) and (17) we can solve the steady state values of X , Y , and λ . Note that the real variables are determined in isolation from the monetary variables.

Given λ we can solve for the steady state values of m and f from (14) and (15).

4. UNANTICIPATED WORSENING OF THE TERMS OF TRADE

Suppose now e increases unexpectedly and this increase is expected to be permanent. Before analyzing the dynamics let us look at the new long-run equilibrium.

We have the following steady-state effects

$$d\bar{X}/de = (-Y(U_{22} - eU_{12}) - U_2) / (U_{22} - 2eU_{12} + e^2U_{11}) > 0 \quad (27)$$

$$d\bar{Y}/de = (U_1 + YU_{12} - eYU_{11}) / (U_{22} - 2eU_{12} + e^2U_{11}) < 0 \quad (28)$$

$$d\bar{\lambda}/de = Ye(U_{11}U_{22} - U_{12}^2) / -j(U_{22} - 2eU_{12} + e^2U_{11}) > 0 \quad (29)$$

$$d\bar{m}/de = ((\mu + \delta)v_{22} - v_{12}\delta) (d\bar{\lambda}/de) / (v_{11}v_{22} - v_{12}^2) < 0 \quad (30)$$

$$d\bar{f}/de = (-f_j'/j) + (v_{11}\delta - v_{12}(\mu + \delta)) (d\bar{\lambda}/de) / (v_{11}v_{22} - v_{12}^2) < 0$$

$$d\bar{a}/de = (v_{11} - v_{12})\delta - (v_{12} - v_{22}(\mu + \delta)) (d\bar{\lambda}/de) / (v_{11}v_{22} - v_{12}^2) < 0$$

where we have used the property that U is homothetic to evaluate (28).

An increase in the relative price of Y reduces real income and the consumption of Y since both the income and the substitution effects work against it. The income and substitution effects work in different directions in the case of X . For homothetic preferences the marginal utility of real expenditure λ rises. Given the "nominal rate of interest"-- $\delta + \mu$ --the marginal utility of domestic money V_1 has to rise. Also given the "real rate of interest" δ , the marginal utility of foreign money has to rise. In (32) we see that the long run or "target" level of wealth falls.

The terms of trade worsening lowers steady state real expenditure hQ . If it was possible to raise expenditure by increasing interest income agents might have tried that. But since both assets are non-interest bearing, consumption opportunities are constrained by the real value of endowment hQ . This raises the marginal utility of expenditure λ and reduces real wealth. Since the opportunity cost of holding domestic money is fixed across steady states, a decline in wealth means a reduction in both m and g . Since e has risen a fall in g necessarily implies a fall in f (remember $g \equiv j(e) \cdot f$).

Turning to the dynamics we find that since the stable arm is a first order adjustment path any reduction in the level of foreign assets must begin immediately, i.e., we have

$$\dot{f}(0) = s[f(0) - \bar{f}] \quad (33)$$

where s is the stable root so the sign of $\dot{f}(0)$ is that of $\bar{f} - f(0)$. $d\bar{f}/de$ is negative and $f(0)$ is given by history.

The impact effects on m and λ can be calculated from equations (25) and (26).

$$dm(0^+)/de = d\bar{m}/de - n_2 d\bar{f}/de < 0 \quad (34)$$

where 0^+ refers to the moment the unanticipated shock occurs. It is clear from (34) that real balances overshoot the new long run value (by $-n_2 d\bar{f}/de$). This is equivalent to saying that the price level P overshoots its long run path.

The impact effect of e on the co-state variable λ can be seen by analyzing the following equation [equation (22)]

$$\dot{m} = m[\mu - (V_1 - V_2)/\lambda] \quad (35)$$

Now from equation (34) we know that $\dot{dm}(0^+)/de > 0$ and $dm(0^+)/de < 0$ and therefore

$$\begin{aligned} d\lambda(0^+)/de &= ((V_{11} - V_{12})/\mu)dm(0^+) + ((V_{12} - V_{22})/\mu)fj' \\ &+ (\lambda/\mu m)\dot{dm}(0^+)/de > 0 \end{aligned} \quad (36)$$

The short run and the long run effects in the goods markets is analyzed in Figure 1. In Figure 1 along the horizontal axis we measure the endowment Q and the consumption of X . On the vertical axis we have the imported good Y . At the initial terms of trade e_0 the economy is at point C_0 on indifference curve U_0 . With the new terms of trade e_1

the new long run equilibrium is at C_1 on U_1 . In the short run the economy ends by spending OR units of $X > OQ$, implying a current account deficit.

It is clear that agents react to the terms of trade shock by increasing expenditure on goods. By how much does expenditure increase? In particular, do agents react perversely by first increasing expenditure so much that they are on a higher indifference curve than before? To see that this is not the case write [from equations (18) and (19)]

$$U = U(X(\lambda, e), Y(\lambda, e)) \quad (37)$$

$$\text{and } dU(0^+)/de = [(U_{22} - eU_{12})h + (eU_{11} - U_{12}^2)j]U_1(d\lambda(0^+)/de)D^{-1} < 0$$

where $D = U_{11}U_{22} - U_{12}^2$ and $d\lambda(0^+)/de > 0$.

from equation (36). In equation (37), we have used homotheticity of U .

The time path of expenditure and utility is plotted in Figure 2. Utility falls somewhat due to a reduction in real income even though expenditure rises to offset it.

To analyze the effect of an increase in e on the asset markets let us turn to Figure 3. The horizontal axis measures g and the vertical axis m . The points E and E' represent the old and new long-run equilibrium respectively.

Given our assumption that q^* is constant and the change in e is made up entirely of changes in the nominal exchange rate and the (nominal) price of domestic output, we find that an increase in e constitutes capital gains on the holdings of foreign currency ($fj'de = \text{distance EC in Figure 3}$).

OW was the Engel Curve through point E the initial long run equilibrium [slope $OW = 1 + (\mu/\delta)$]. We know from equation (34) that real balances fall sharply on impact and that they are built up again during the adjustment process (though the new long run level at E' is lower than at E). The instantaneous equilibrium must be at the intersection of the vertical line through C (because in the short run the economy must willingly hold the given g) and an Engel Curve such as OW', implying that the opportunity cost of holding real balances rises.

There are two apparent puzzles here. First, if real balances are to rise along the adjustment path then \dot{P}/P must be lower than μ . How does the opportunity cost of holding money rise so that $m(0^+)$ is negative, when \dot{P}/P falls from its previous value of μ ? The answer is found by looking at the slope of the Engel Curve OW' given by $1 + (\dot{P}/P)(\delta - \dot{\lambda}/\lambda)^{-1}$. For OW' to be flatter than OW we require that $\dot{\lambda}/\lambda$ rises sufficiently so that the denominator falls by more than the numerator.

The second apparent puzzle is about the level of real wealth. It can be readily checked that $da(0^+)/de = d\bar{a}/de - n_3 d\bar{f}/de$ where $n_3 < 0$ so $da(0^+)/de < 0$. The dynamic evolution of real wealth is like that of real balances, the short run level overshooting its new (lower) long run value. In the adjustment process financial wealth is built up (by \dot{P}/P lagging behind μ) as f is run down through a current account deficit. In the flexible exchange rate regime, where the domestic currency is non-traded, savings rise following a terms of trade shock but the current account goes into a deficit (remember \dot{a} is the difference between augmented income and augmented expenditure).

The intuitive explanation is as follows. Following a rise in e , the economy experiences an increase in g . In the short run this g must be willingly held so the opportunity cost of holding domestic money must rise (relative to foreign money). This lowers the level of real balances so much that a actually falls (in spite of the fact that g rose due to the increase in e). Over time g falls and m and a are built up.

Going back to Figure 3 we see that the short run equilibrium occurs at D where wealth is lower than both E and E' . Over time OW' rotates back towards OW in counter-clockwise manner.

The time paths of a , m and f are shown in Figure 4.

In the short run utility from goods and assets falls. That U would fall has already been shown in (37). To check that V also falls write

$$V = V(a-g, g)$$

so that

$$dV(0^+)/de = v_1 da(0^+)/de - \lambda u f_j' < 0. \quad (38)$$

5. NON-TRADED GOODS

In this section we extend the model to include a non-traded good. The non-traded good we shall consider is leisure.⁸ The supply of the exportable becomes variable being a function of the labor input. The only difference between leisure and any other non-traded good or service is that the price of leisure does not enter the price index used to deflate nominal variables.

We also assume leisure (ℓ) enters the instantaneous utility function in an additively separable way. This is an overly strong restriction but makes the algebra easier (Michener (1984) makes a similar assumption).

The household's utility functional now becomes

$$\int_0^{\infty} \exp(-\delta t) [U(X(t), Y(t)) + b(\ell(t)) + V(m(t), g(t))] dt \quad (39)$$

where $b' > 0$, $b'' < 0$ and the flow budget constraint becomes

$$\dot{a} = h(w(1-\ell) + \Pi - X) - jY - (P/P) \dot{m} + T \quad (40)$$

where w is the product wage rate and Π the household's share in profits, both given parametrically. The household's time endowment is unity so $(1-\ell)$ is the labor it supplies to the firm.

The additional first order condition for the household's problem is given by

$$b'(\ell) = \lambda hw \quad (41)$$

which is the usual condition that the consumption of leisure proceeds to the point where it is equal to the marginal utility of the wage rate.

The representative firm maximizes its profits over time. Labor is assumed to be the only input so its dynamic optimization problem reduces to a static one. Assuming the number of firms is equal to the households, the firm's maximization problem is

$$\max \Pi = Q - w(1-\ell) \quad (42)$$

where Q is the level of output produced according to a concave production function with the usual properties

$$Q = Q(1-\ell) \quad (43)$$

$$Q' > 0, Q'' < 0$$

The first order condition for (42) is

$$Q'(1-\ell) = w. \quad (44)$$

In a perfect-foresight equilibrium therefore it must be true that

$$b'(\ell) = \lambda h Q'(1-\ell) \quad (45)$$

To see that the main results obtained in the previous sections remain unaltered let us first turn to the long run comparative statics.

$$\begin{aligned} d\bar{\lambda}/de &= -[(g'' + \lambda h Q'')(y + \lambda Q'^2 h')(U_{11} U_{22} - U_{12}^2)]/h[Q'^2(U_{11} U_{22} - U_{12}^2) \\ &\quad - (b'' + Q'' U_1)(2e U_{12} - e^2 U_{11} - U_{22})] > 0 \end{aligned} \quad (46)$$

where again we have used the homotheticity of U .

$d\bar{\lambda}/de$ cannot be signed but $d\bar{y}/de < 0$ as before.

Since $d\bar{\lambda}/de$ is still positive the signs $d\bar{m}/de$, $d\bar{f}/de$ and $d\bar{a}/de$ are the same as in (30), (31) and (32) respectively. That is across steady-states we still have wealth, real balances and stock of foreign money declining.

Returning to the dynamics now we find that the only term in the coefficient matrix A in (23) which needs modification is a_{13} . That now becomes equal to

$$a_{13} = j(U_{22} + e U_{11} - 2U_{12}) - h Q'/(b'' + \lambda h Q'') > 0. \quad (47)$$

We can therefore be sure that the qualitative properties of the economy's adjustment path following an unanticipated terms of trade deterioration that we derived earlier continue to hold. In particular, the stable arm is a first order path and the economy saves while running down foreign money following the terms of trade shock.

6. CONCLUSIONS AND QUALIFICATIONS

We have analyzed the Laursen-Metzler Effect in an optimizing model where there is no capital mobility. Currency substitution allows money flows and does not require the restriction that trade be balanced at each point of time. In such a framework we found that an unanticipated permanent change in the small country's terms of trade lead to a sequence of current account deficits. Along the adjustment path, the economy's saving is also positive.

It is important to realize that our results were obtained from a model where domestic and foreign moneys yield utility and where barter is infeasible. The transactions technology underlying such a specification is not spelled out clearly at all.

Changes in model specification would not overturn the results of this paper as long as we are in a world of capital immobility. Such a world was the setting of Laursen and Metzler's model.

It is interesting to note a parallel between the results obtained here and the consumption-function-rational expectations literature. There liquidity constraints were used to explain the observed serial correlation of consumption. In this paper, we have used capital immobility to explain the current account response of a small open economy to a terms of trade shock.

FOOTNOTES

1. See Kouri (1983) for a discussion of various approaches to modelling dynamic optimization problems in an open economy.
2. Additive separability is too strong an assumption but it certainly simplifies the algebra and gets us around problems of non-uniqueness that might be associated with models where money enters the utility function.

The author does not think that money-in-the-utility-function approach can be defended theoretically. But most recent macro-economic models with optimizing agents assume this and so do we. See also Feenstra (1984) where it is shown money-in-the-utility-function is isomorphic to a liquidity cost constraint.

3. Liquidity-constrained in the sense that to run a current account deficit, foreign currency is required to finance it. Note we have assumed $V(m, 0) \rightarrow \infty$.
4. See Liviatan (1981) and Calvo (1985) for a discussion of co-operancy of assets in a similar framework. Note that unlike Liviatan co-operancy is only a sufficient condition for the main results, e.g., in equation (31).
5. I am grateful to Professor N. Kiyotaki for a discussion on this point.
6. This is an arbitrary way of imposing stability but very common in the rational expectations literature.

7. For a similar diagrammatic apparatus see, e.g., Frenkel and Rodriguez (1975).
8. Bean (1983) analyzes the choice between labor and leisure in the two period model of Svensson and Razin (1983).

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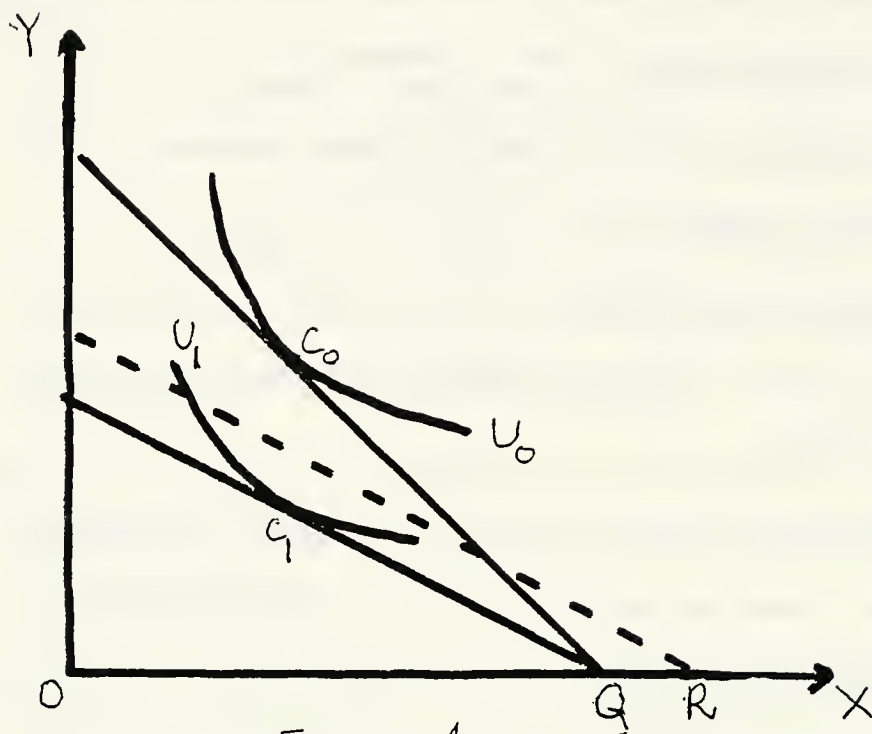


Figure 1

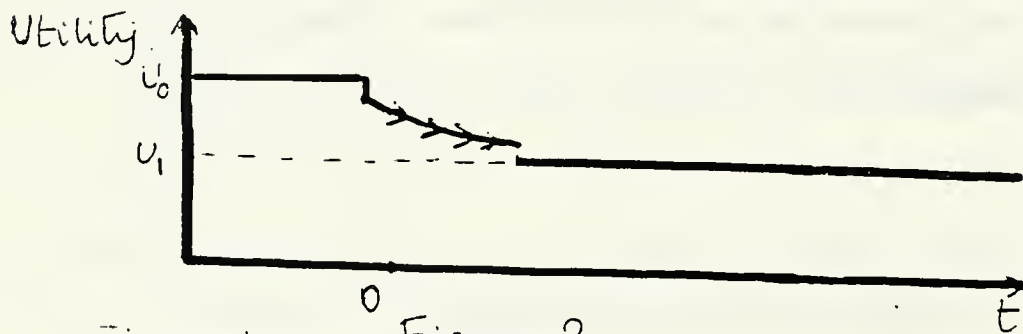
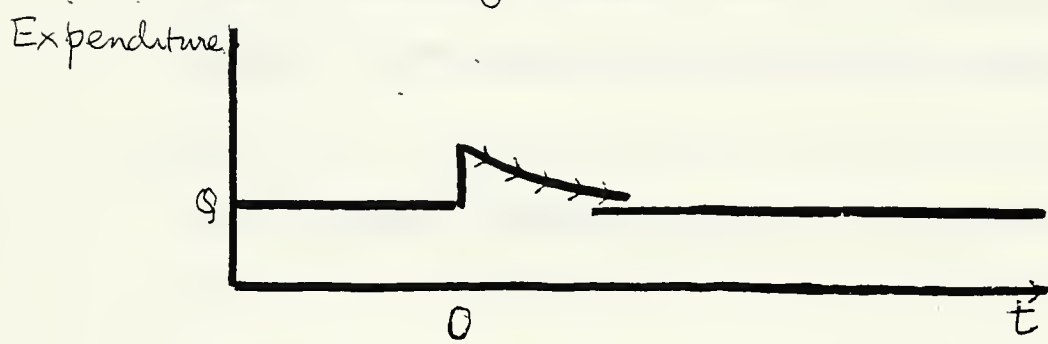


Figure 2

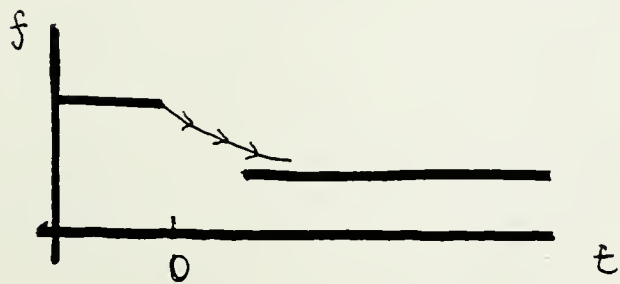
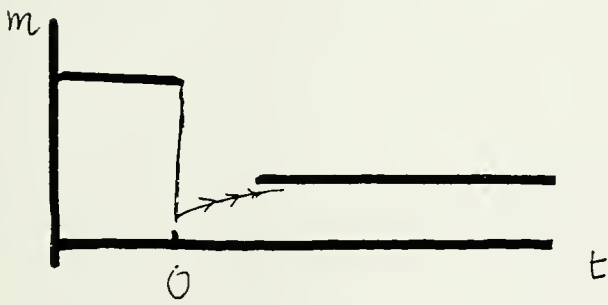
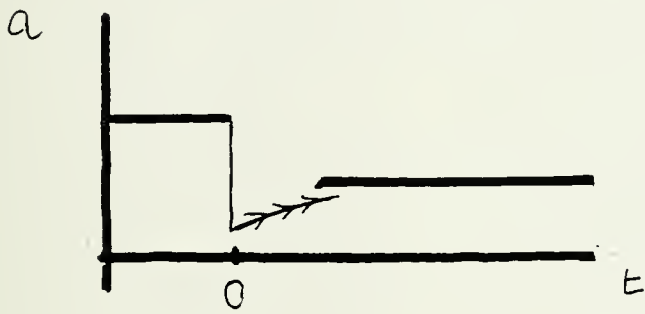
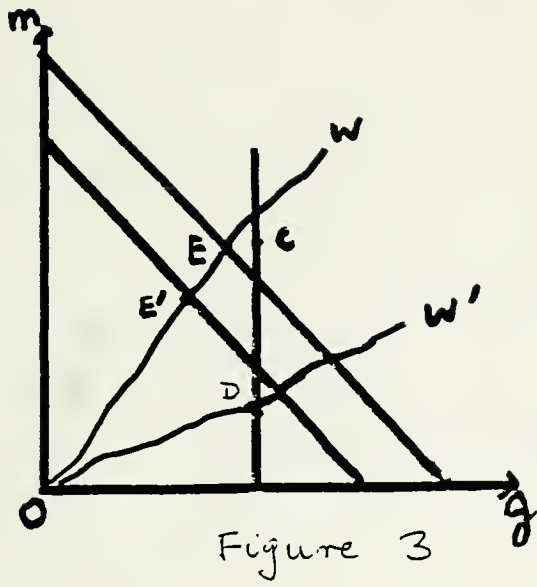


Figure 4.

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